WEIGHT

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CORNELL RURAL SCHOOL LEAFLET

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CORNELL RURAL SCHOOL LEAFLET

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WEIGHT

Almost everything we do is influenced to some degree by weight, the subject of this Leaflet. Youngsters surprise one another by throwing things wildly into the air and yelling:

"All that goes up must come down
On your head or on the ground."

When they hear that rhyme they know that something is unsupported in the air above and that if they do not take care it might hit on the way down. Later they learn Longfellow's poem which begins:

"I shot an arrow into the air
It fell to earth, I knew not where."

Perhaps the author, as a boy, may have hurled things into the air to see them come down again.

Throughout his life man experiences the force of gravity. It is probably most conspicuously demonstrated when it draws things towards the center of our earth. Some of the experiences with gravity are fun; others are not. Riding down hill on a sled or coaster is fun as long as the sled does not go too fast and can be stopped at will. Throwing a baseball, kicking a football, or riding an airplane give much satisfaction if the place and speed of landing are controlled. When you receive a wrapped Christmas present probably the first thing you do will be to feel how heavy it is to get some idea of the contents.

TO STUDY WEIGHT

Provide yourself with two bottles (quart milk bottles or fruit jars will do), two old rubber toy balloons, a flower pot, a quart measure, some strings, about a foot of stove wire, some sand or shot, three or four feet of rubber tubing or rubber hose, a good-sized aquarium or two pails, a foot ruler, and a few rubber bands. With these you may experiment to gain an understanding of the subject of this Leaflet.

Simple Weighing Experiments

Fasten a string firmly around the middle of your ruler. Fasten wire hooks from each end of the ruler at equal distances from the center.

Make a wire or string bail or handle for each bottle. Hang one empty bottle at each end of the ruler. With the central string raise ruler and bottles. The ruler should come to rest horizontally. If it does not, wind enough wire around the neck of the bottle which is suspended the higher to make the two bottles balance. With this simple scale, you can weigh a great number of things.

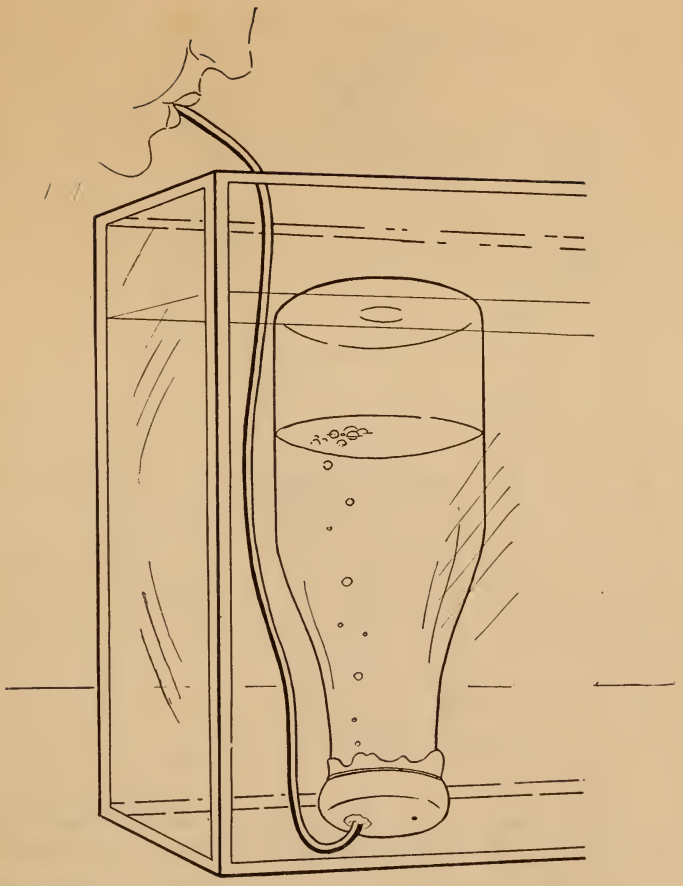
Pour a pint of water into one bottle. How much must you pour into the other to have them balance? Does this hold true for other amounts? Pour a pint of sand or pebbles into one bottle. Will it be balanced by a pint of water in the other? Will it be balanced by two pints of water? Of equal volumes of sand and water, which weighs more? Pour some of the sand into the water. Does it sink through the water or float on top of it? Compare the weight of one-half cup of oil such as is used in automobiles, with the weight of a similar amount of water. Does oil float on water or does water float on oil? Try the same experiments with a pint of sawdust or with other materials.

Put a cup of water in one of your bottles. In the other bottle put a cup of sugar or salt. Do the two balance? Which is the heavier? If you pour one into the other will the lighter substance float on top of the heavier?

Experiments with Floating Bodies

Cut a small hole in a sheet of rubber, which can be obtained from a rubber balloon. Through the hole, thrust the end of a rubber tube. Bind the piece of rubber to the tube with string, a rubber band, or rubber cement. Near where this tube pierces the balloon cut another small hole. Fill one of your bottles with water. Stretch the rubber over the mouth of the bottle so that the tube opens into the bottle and the hole is over the mouth of the bottle. Partly fill a pail with water. In it place your water-filled bottle with the tube attached. Does the bottle float? Hold the bottle with its mouth downward and blow into the tube. Bubbles of air will rise in the bottle. Continue blowing until the bottle changes its position. Eventually the bottle will begin to rise. Can you find a point where by gently blowing or sucking on the tube you can make the bottle rise just to the surface or fall? The principle demonstrated by raising the bottle is applied in raising sunken ships. Great drums are sunk near the ship. They are then filled with air, which exerts such a pull that the ship is lifted.

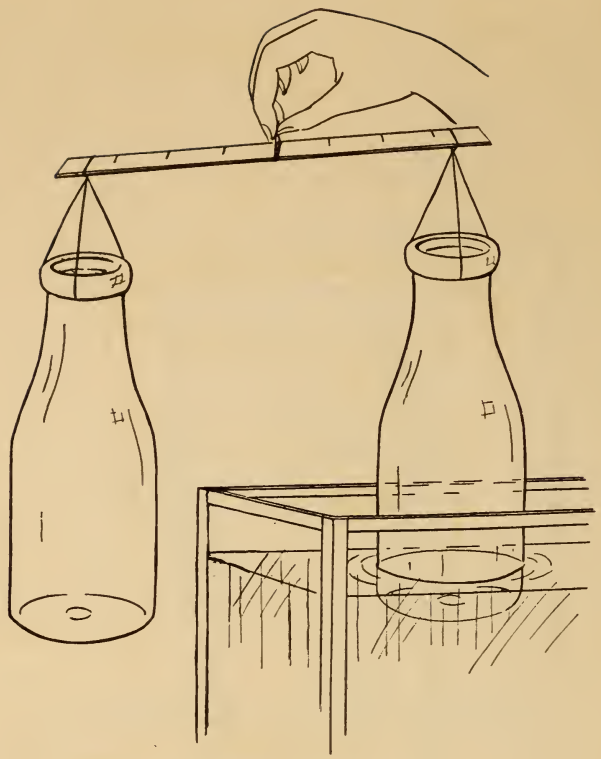
Cover the mouth of one of the bottles with a piece of a rubber balloon stretched flat but not too tight. Force the bottle under water and notice the effect on the rubber. Does it bend inward or outward or remain



WOULD THE BOTTLE FLOAT WITH THIS QUANTITY OF AIR IN IT?

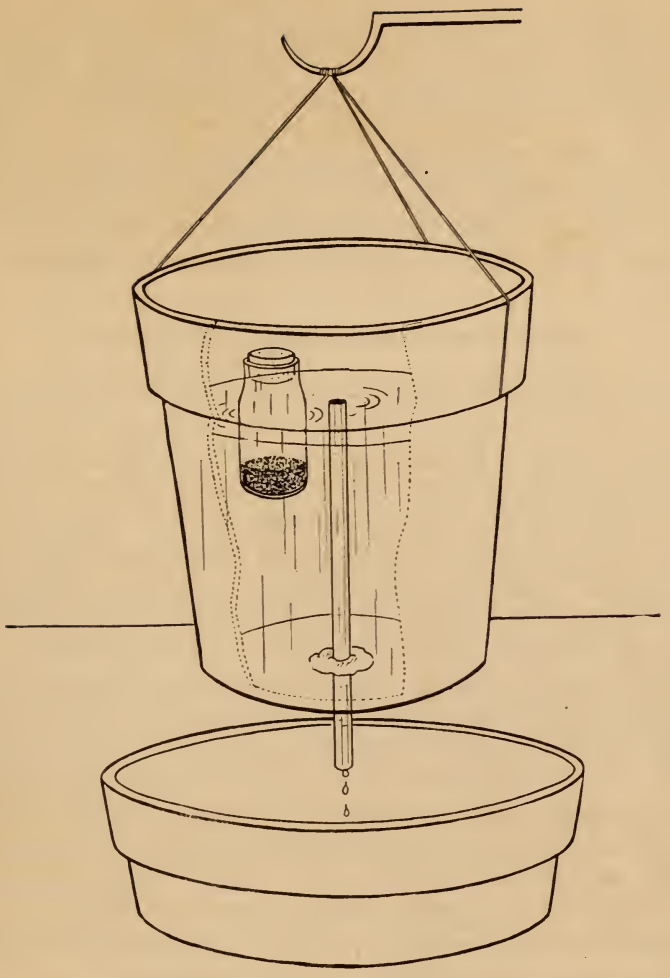
flat? Is the pressure outside the bottle greater under the water surface or above it? Does this experiment help you understand why your ears are affected by diving deep into the water? Or by climbing a mountain, or by flying from great heights in an airplane, or even by going up and down in an elevator in a high building?

Fill a pail or aquarium nearly full of water. Put a pint of water in each of the bottles you have been using and balance them on the ruler, as suggested in the first experiment. Hold the bottles so that one is suspended over the pail of water. Lower the balance so that the bottle may sink into the water. Does this upset the balance? How? Do you think that an object would weigh more in air or in water or would it weigh



the same no matter where it was? Why can you swim through the water and not through the air? Would it be easier to draw a canal boat loaded with coal from a tow-path beside the canal or to haul a freight car loaded with a similar amount of coal along a track, assuming that the car and the canal boat weighed the same and that air and water offered equal resistance? Would it be easier than either of these to haul it by airplane? What would the airplane have to do that the coal car and the boat could shift to the supporting land or water? If time did not count would you expect that it would be cheaper to ship things from New York by rail, by sea, or by plane? Why is it cheaper to tow log rafts through water than to haul them overland?

Through the hole in the bottom of a flower pot thrust a glass tube so that one end is nearly level with the lower edge of the flange on the pot and the other end hangs below the smaller end. Cement the tube in place with wax or cement. Place a dish below the tube and suspend the pot over the dish. Fill the pot with water up to the end of the tube. Be sure



DESIGNED BY PHILIP JOHNSON

APPARATUS FOR STUDYING DISPLACEMENT OF A LIQUID BY A FLOATING BODY

that the dish below is free of water. Float some object in the water beside the tube, using possibly a bottle partly filled with sand or shot. Weigh the amount of water that is forced to flow through the tube as an overflow when the object is floated. Do this by weighing the dish and the over-flow water and from this weight subtract the weight of the dish alone. Weigh the object which was floated. Compare the weight of this object with the weight of water which it displaced. If you wish you may use your milk-bottle balance, collecting the overflow water in one bottle

and placing the object to be floated in the other. Which of the two bottles seems the heavier, if there is any difference? What would you say about the relationship between the weight of an object and the weight of the amount of water it displaces when it floats? Incidentally the same principle which governs the floating of bodies in water governs the floating of bodies in any other fluid, whether this is molasses or air. If you can understand this principle and demonstrate it you may understand why balloons ascend, why one swims more easily in salt water than in fresh and what we mean when we say that a ship has a displacement of so many tons.

Experiments with Weights in Motion

Stick seven thumb tacks into the moulding along the upper edge of the blackboard, each six inches from its neighbor. Tie a nail or other small weight to the end of a three-foot string. Make a loop in the other end of the string and slip the loop over one of the thumb tacks. Draw a line on the blackboard from the tack to the weight. Move the string and weight to the next tack and draw another line along the string. Repeat with each tack. The lines will appear to run parallel to each other. The strings are really plumblines and are essentially like those used in building skyscrapers and other tall structures. Number the lines from left to right.

Hang the string loop over the middle thumb tack. Keeping the string taut, move the weight over so that it is near the farthest line to the right. Release the weight and watch carefully to see how far the weight swings before it changes its direction of movement. Does it stop when it is immediately below the center thumb tack? Does it swing as far to the left as the line farthest to the left? If you leave the swinging weight untouched where does it eventually come to rest? As the swings become shorter are they more frequent? That is, when the *pendulum* as we may correctly call it, is about to come to rest does it make more back-and-forth swings in five seconds than when it is swinging widely?

Make three string pendulums similar to the above, one with a string one foot long, one with a string two feet long, and one with a string three feet long. Use equal weights on all three pendulums. Hang them on different thumb tacks and set them all to swinging, starting them at the same time. Do they all swing with equal rapidity? If they vary, which swings most rapidly? Would a clock with a long pendulum tick oftener than a clock with a short pendulum? Check this on a pendulum clock. How would you adjust a pendulum clock if it gained time?

The force which draws the pendulum downward is *gravity*. That which carries it beyond the plumbline is *momentum*. If the momentum equalled

the pull of gravity the pendulum would swing forever if there were no friction between the swinging pendulum and the air. This friction is important as to most moving objects. To overcome it, at least partially, "streamlines" are used in automobiles, boats, trains, torpedoes, and other machines.

Take three bottles of the same size and attach them to the ends of three-foot strings. Fill one bottle with some light substance such as cotton. Fill the second with some heavier substance such as water. The third should be filled with something still heavier, such as sand or shot.

Set these pendulums to swinging all at once. Is there as much difference in the way these swing as when you used equal weights on three different lengths of string? Would you expect a ten-pound weight to fall more rapidly or less rapidly than a two-pound weight of the same size, or would the two fall at the same rate?

When you are outdoors stick an apple on one end of a stick or whip about three feet long. In an open space where you can do no damage, swing the whip in a vertical circle. What happens to the apple? Can you control the direction in which the apple goes by increasing or decreasing the speed with which you swing the stick around? After the apple leaves the stick does it go for awhile in a nearly straight line or does it continue to follow the circular motion? This tendency for things to fly off from such a circular motion is important in many devices used on the farm. The Babcock milk tester, the cream separator, the governor which makes a phonograph disc whirl uniformly, all use the principle of centrifugal, or flying-from-center, force.

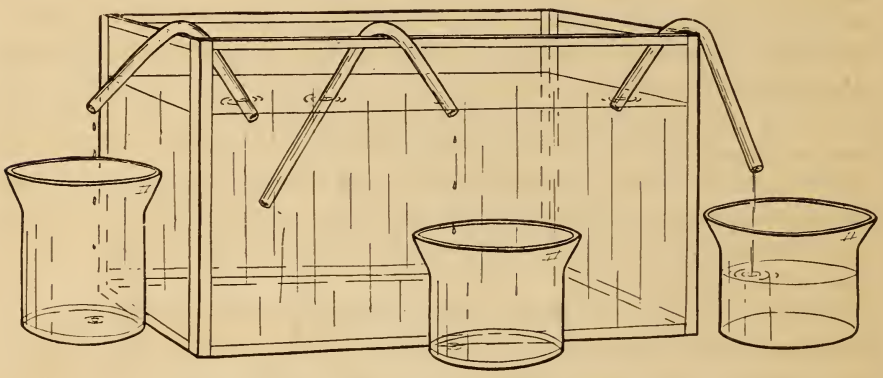
When your apple leaves the stick and flies into the air does it seem to increase its speed as it goes up, then stop suddenly and return to the ground at a uniform speed, or is there some other change in speed? An arrow, bullet, or sky rocket, shot upward has to push its way through the air. If this were not true would you expect it to come back to the ground as swiftly as it left? In a later Leaflet we will make a more detailed study of the laws governing falling bodies. Give reasons why you think it is safe or dangerous to shoot an arrow, an air gun, or a rifle aimlessly into the air.

In Balance and Off

Set up your milk-bottle-ruler balance again. Take a piece of hose or rubber tubing about four feet long. Fill it completely with water. While it is full pinch the walls together exactly in the middle and empty the water in one-half the hose into one bottle and the water in the other half into another bottle. Weigh the two to see if the water in the bottles is about equal in weight. Make a mark on the hose where you squeezed it.

Fill the hose again with water. This time pinch it at one-fourth of its length, or so that the distance on one side of your hand is about three times that on the other side. Empty the water from the shorter part of the tube into a dry, empty milk bottle and that from the longer part into another. Weigh the two. Which is able to pull the other up?

Now set a pail of water on a table or desk and below it on the floor an empty pail. Fill the hose with water and pinch it in the middle. Have someone hold the two ends so that none of the water is let out and place the hose so that the ends hang downward, one in the full pail and one out. The ends of the hose should be at the same level and just below the level of the water in the pail. The squeezed spot in the middle should rest on the edge of the pail. Let go of the squeezed portion of the hose and see what happens to the water in it. Does a great amount run into the empty pail? Does the water continue to flow from the full pail into the empty pail?



AN EXPERIMENT IN SIPHONING WATER

Repeat this process, squeezing the hose at a point one-fourth of the distance between the two ends and placing the squeezed point at the edge of the full pail with the shorter section outside. How does what happens differ from what happened in the preceding experiment? Repeat this experiment, letting the longer portion of the hose hang over the empty pail and the shorter portion remain in the full pail. How does what happens differ from what happened before?

In the last experiment you have a *siphon* working. The water in the longer portion of the hose, weighing more than that in the shorter portion, keeps flowing out, pulling more water in, and finally empties the pail. This way of getting water over an elevation without work on your part is worth knowing. If you wish to remove water from an aquarium it is

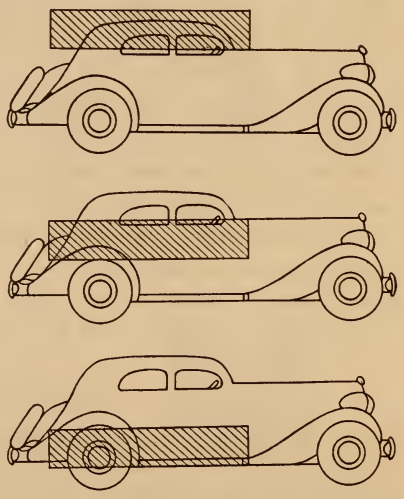
much simpler to use a siphon than to dip the water out. Most large water systems that bring water from considerable distances use the principle of the siphon to get the water over hills or low mountains. In the trap in the toilet or wash basin the siphon system is employed. It keeps a plug, or seal, of water between your room and the sewer into which the waste water goes, and in this way prevents unpleasant and dangerous sewer gas from spoiling the air of your home.

Test your rubber-tube siphon to determine whether the important thing is that more than half of the tube should be outside and lower than the water surface. Could water be siphoned by putting most of the tube under water but making sure that at least some of the tube outside is below the surface of the water?

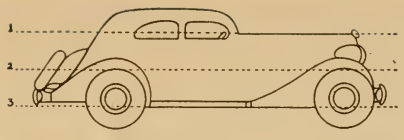
In the siphon experiments you noted the effect of trying to balance what appear to be two unequal weights. Apparently unequal weights may balance nicely. Cut from thin cardboard or heavy paper a bird or airplane. Place an equal number of paper clips of the same size along the front of each wing. Now estimate where you think a supporting finger would balance the figure. Is it in the middle? Find out at what point the figure is really balanced and explain the difference.

Take a half-dozen small toy automobiles such as may be bought at a five-and-ten-cent store. With cards, make a curved track down which they may coast. Make a paper box which will fit on the top of each car or provide a lining so that the cars may be loaded with sand which will not leak out. Fill one of the cars with sand and place the load low in the car. Leave a second car unloaded. Fill a box on the roof of the third with sand. To the top of each of two cars fasten a card large enough to make the car seem top-heavy. Fill the lower part of one of these cars with sand and leave the other empty below. Fill the sixth car with sand and also fill the box on top.

Decide by rolling the cars down the track which of them may be coasted down the track without upsetting. Draw outlines of the cars and loads on cards by laying the cars down on their sides and tracing around them. Indicate by shaded areas the regions where the heavy loads are carried. Where are these



WHICH OF THESE CARS, IF LOADED AS INDICATED, WOULD UPSET MOST EASILY?



ALONG WHICH LINE OR NEAR WHICH LINE WOULD THIS CAR BALANCE?

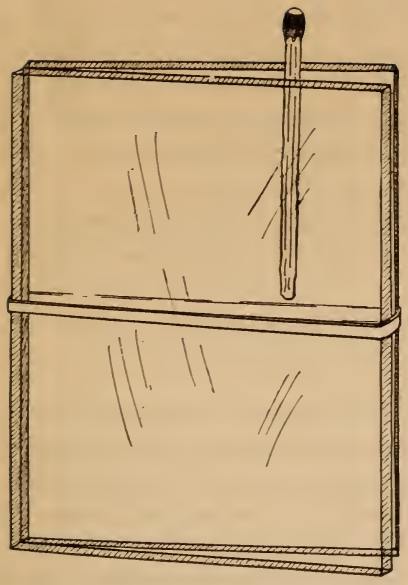
shaded areas in the cars which were most successful in coasting down the track without upsetting? Lay the cars on their pictures on the cards after fastening the loads in with paper covers. Lay a narrow stick on the table or hold a ruler on edge. Now try to balance the car-loaded cards on the edge of the ruler, and, when you succeed, draw a line through the length of the picture of the car at the point or line where the ruler edge is. Do you notice any relationship between the position of this line between the top and bottom of the cars and their ability to coast down the track successfully? Presumably this line would pass through what is known as the *center of gravity*. A line running from top to bottom of the cars, along which the car may be balanced, would also pass through the center of gravity. The point in this line where the car could be supported erect without falling to either side would be at this center.

Much of the high-speed automobile travel has been made possible by gradually lowering the center of gravity. Models of different years of the same makes of cars show how the newer cars have been designed to lower this center of gravity.

Observe ways in which the center of gravity may be placed advantageously. Why can one coast down hill more successfully lying down than standing up? Why are the bases of power-line towers or windmill towers wider than their tops? Why do the most successful canoeists kneel on the bottom of the canoe rather than sit on a seat supported above the water? Of what use is an outrigger on a canoe? Why do sailors of canoes or small boats sit as far as possible to one side when the boat tips? Why do fish have paired fins? Are the more conspicuous of these fins near to, or far from, the heaviest part of the fish? What do you think is the reason? Why do babies, when they first walk, walk with their feet wide spread? Why do old folks use canes? Why do sailboats have heavy keels? Why does a bicycle tip over more easily than a tricycle? Why do tightrope walkers carry a long pole? Of what use are the tails of squirrels, deer-mice, birds? When the farmer's wife cut off the tails of the "three blind mice" did she help protect her pantry?

Forces Against Gravity

In one of your earlier experiments with a pendulum you saw how the momentum of a moving body might work against the force of gravity and pull the weight upward.

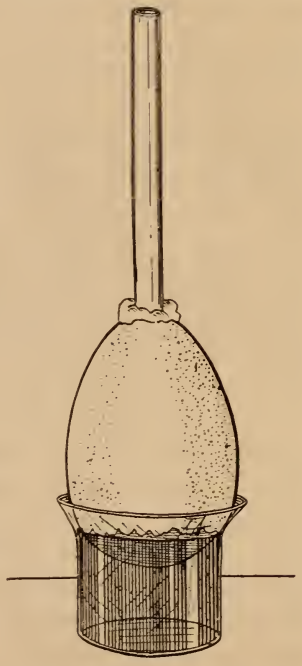


SIMPLE DEVICE FOR DEMONSTRATING CAPILLARITY

In the experiment with the siphon you saw how a strong downward pull might serve to counteract a less strong pull. You saw this also in the first experiment with the milk bottles where the stronger pull of the heavier weight triumphed. These stronger forces may be developed variously as shown with the experiments with heating water suggested on pages 15 to 22 of the Leaflet entitled "Heat."

With two small sheets of glass held together with a rubber band and then separated along one side by slipping a match between two edges, you may demonstrate another force which acts against gravity. Set these glasses in a dish of water with the open edges vertical, or in an upright position. Notice whether the water rises equally along the closed edges and the open edges. The force which makes the water rise as it does is called *capillarity* and it plays an important role in nature. It is probably one of the forces which helps raise water to the tops of our highest trees to support life in the leaves. It undoubtedly helps keep our soil moist instead of watersoaked or dusty.

Chip the shell off the large end of an egg over an area about the size of a quarter, being careful not to break the membrane inside. The shell may be removed with dilute acid if you do not succeed in doing it otherwise. With wax, gum, or household cement fasten a piece of glass tubing to the small end of the egg. Thrust a wire through this tube and break the shell and membrane just beyond the end of the tube. Put some water and red ink in a cup and place the egg in this with the large end down



EQUIPMENT FOR AN EXPERIMENT IN OSMOSIS

and the tube erect. Leave this for some hours and you will notice that water rises in the tube. This is not because of capillarity, momentum, or any of the other forces so far discussed but because of *osmosis*. By osmosis, the water passes through the membrance into the egg with enough force to lift a column of liquid upward through the tube. This force, with capillarity, helps keep the tops of trees moist.

Other forces may work against gravity to raise things from the center of the earth but these will be discussed in a later number of the Leaflet.

WEIGHT IN AGRICULTURE, COMMERCE, AND INDUSTRY

Until recent times, much trading in agricultural produce was carried on with little attention to weight. Eggs and potatoes, were bought or sold by dozens or by bushels. That day is passing and it should. Nowadays potatoes, carrots, bananas, and many other products are bought by the pound. Even eggs are graded according to weight. Care is taken that foreign matter has not been introduced to change the weight. Sand in sugar, nails in ginseng roots, quartz in clover seed and lead in fabrics are either illegal or in bad repute; and the time may come when truth will be demanded in advertising. A salesman may sell you a "package" of some product and you may be misled in what you buy because a package may be of any size or weight, or may be marked to weigh a pound without specifying the weight of the contents. A pound package, therefore, may not contain a pound of the desired commodity. The buyer must be continually on guard against misrepresentation or misleading statements if he wishes to receive a fair return for his money. Possibly this exactness in weight of produce in commerce has been most effectively established in the standardization of milk. An unscrupulous man does not profit by watering his milk if he knows that the milk he delivers must contain at least a certain proportion of animal fat.

Some States have recognized the possibility of unfairness in buying by volume rather than by weight. In New York for example certain things, if sold by the bushel, must also weigh a certain amount. Other States which have similar rules are California, Delaware, Illinois, Kentucky, Minnesota, Missouri, Montana, New Hampshire, New Mexico, North Dakota, Oklahoma, Pennsylvania, South Carolina, Texas, Vermont, West Virginia, and Wyoming. Arizona and Washington have no legal or standard bushel weight; in Mississippi and North Carolina a legal weight need be observed only when the purchaser demands it. To determine the

cost of import duties, the Federal Government has certain standard weights for bushels.

Under the Federal Law a bushel of green or ripe apples must weigh at least 50 pounds. A bushel of barley must weigh 48 pounds; of cracked corn, 56 pounds; of hulled or unhulled oats, 32 pounds; of peas, 60 pounds; of rye, 56 pounds; and of wheat, 60 pounds.

Although there is no legal weight for a bushel of apples in New York, the State insists that a bushel of beans weigh 60 pounds; bran, 20 pounds; buckwheat, 48 pounds; clover seed, 60 pounds; cornmeal, 50 pounds; flaxseed, 55 pounds; timothy seed, 45 pounds; lime, 70 pounds; coarse salt, 70 pounds; fine salt, 56 pounds; carrots, 50 pounds; dried peaches, 33 pounds; and dried apples, 25 pounds.

In Pennsylvania a bushel of coal must contain 75 pounds of anthracite coal or 80 pounds of bituminous.

Weights of other farm produce not necessarily established legally may be useful in determining the weight of loads to be hauled. A cord of hickory wood weighs slightly more than 2 tons, or 4468 pounds. The same amount of red oak firewood weighs, 3255 pounds; of ash, 3449 pounds; of hard maple, 2864 pounds; and of beech, 3234 pounds.

Ten eggs generally equal a pound in weight. At 68° F., milk with 3 per cent butterfat weighs 8.6 pounds to a gallon; cream with 28 per cent butterfat, 8.37 pounds; and cream with 40 per cent butterfat, 8.28 pounds to a gallon.

Those who help in housework may find it convenient to know that generally a quart measure holds a pound of wheat flour, or broken loaf sugar, or 1 pound and 2 ounces of corn meal or brown sugar, or 1 pound and 1 ounce of powdered white sugar.

Weight does not furnish the only basis on which the worth of a product may be determined. Quality is important. A pound of chicken is not always the same. It makes considerable difference whether the pound refers to live weight, to dressed weight, or to other weights. If the pound is a portion of a large fat chicken it will make a better meal than if it comes from a more scrawny bird. For this reason farmers may select with care the stock they use, depending on the products they wish to sell. If their best market is for dressed animals they select animals whose dressed carcasses will represent a larger proportion of the live weight than they would if the animals were to be sold alive. Such breeds of cattle as shorthorns, Angus, and Herefords dress a greater proportion of merchantable carcass than the dairy types such as Holsteins and Jerseys. Anyone with farm experience with poultry would readily recognize a corresponding difference between Rhode Island Reds and

Leghorns. To some extent buyers protect themselves. For produce of varying quality to be eaten or to be sold, they pay amounts which are proportionate to the returns which they expect.

In cold weather a car owner tests the water in his automobile radiator to see if it may freeze. He draws some of the water into a glass tube within which is a floating glass device. On the float are marks which indicate where the water level should be with the mixture at various temperatures. The more alcohol and the less water, the lower this device will sink. It may help you to understand this if you weigh a cup of water and a cup of alcohol on your milk-bottle balance. The instrument used in the automobile measures what is called the *specific gravity* of the mixture. The principle which makes it possible for you to swim more easily in salt water than in fresh water is employed. If you buy formalin to treat oats for smut, acid to test your milk, or many other products, you may notice the letters s.g. on the labels; this means specific gravity. With the acid it may be to your advantage to have this high. With alcohol, gasoline, and oils it should be low. See if you can find the letters s.g. in labels or advertisements of oils, gasoline, or other products.

Another common experience with weight of mixtures is associated with jewelry. Jewelry may be marked *18 K*. The K stands for *karat,* or *carat,* or a 24th part of the whole. Thus, a ring that is 18 K gold is 18/24 or ¾ pure gold and consequently of high quality. Could you have a ring 30 K? Pure gold is too soft for use in jewelry which must stand much wear and which must hold jewels in place.

The amount of gold or other metals in coins is fixed by law. The amount may be fixed by a single government or internationally. You have probably heard of governments going off the gold standard a few years ago. This meant essentially that the government which made the change had decided to vary the amount of gold in its unit of money. This changed the value of that nation's money in terms of the money of other nations and naturally confused trade relationships. In general, going off a gold standard or changing the weight of gold back of money means reducing the amount of gold, which reduces the value of money itself and increases the number of dollars needed to buy things.

The field in which values and weights meet may be confusing. For example, what is meant by a ten-penny nail? The term arose when a pound of each of the different sizes was actually sold for the specified number of pennies. Manufacturing and other costs changed, confusion arose, and prices by weight changed; but, strange to say, the old names still persisted. Modern manufacturing methods have changed nearly everything about nails except the common names. One standard now

followed is that of the American Steel and Wire Company which uses the following table:

Penny	Inches	Wire number	Number of nails to pound
2	1	15	876
3	1¼	14	568
4	1½	12½	316
5	1¾	12½	271
6	2	11½	181
7	2¼	11½	161
8	2½	10¼	106
9	2¾	10¼	96
10	3	9	69
12	3¼	9	63
16	3½	8	49
20	4	6	31
30	4½	5	24
40	5	4	18
50	5½	3	14
60	6	2	11

A keg of nails weighs 100 pounds. The cost of nails by the keg differs greatly from the cost by the pound or half-pound.

The term *shekel,* which you may have read in the Bible or used as slang for cash, illustrates another instance in which weight and value are closely associated. The shekel was really a unit of weight and equalled 10 pennyweight in our Troy Weight.

The Biblical term *talent* does not refer to ability to do something well. Instead it refers, like the shekel, to a unit of weight equal to 3000 shekels, or 125 pounds. This is about the average weight of a young person of eighteen or twenty.

WEIGHT AND WAR

Weight plays a great part in the mechanics of war. Man's ability to hurl weights decides the fate of warring nations. In the earliest wars men undoubtedly used the weight of their own bodies against their enemies. They then learned to use sticks and stones which they hurled or rolled from embankments. These practices were improved upon by bows, catapults, and similar weapons, which placed missiles more effectively. Later, explosives were used to hurl bullets and bombs. In a future war, man may employ radiant energy to offset the effectiveness of present-day war machines, and mere weight will not "carry much weight."

The strength of armies cannot be so conveniently assessed as that of navies. For this reason, in part, the attempt to bring about disarmament of nations began through limitation of the size of navies, because size of navies can be reckoned in terms of the amount of water displaced in floating their ships. When we read that the British navy displaces 1,158,659 tons of water and the Italian navy, 370,000 tons, we know that England must have a decided naval advantage, other things being equal.

The history of the earth is full of examples of smaller animals conquering larger. Men may boss elephants, but in turn, they may be driven out of certain parts of the earth by the diminutive tsetse fly. The study of bacteriology indicates the ruling of the massive living things on the earth by the minute ones. David slew Goliath. Small airplanes protected London and Paris from the giant German dirigibles.

The activities of peace should be more than sufficient to keep men busy mastering nature. Airplanes and balloons are not yet safe enough or cheap enough.

Man has only begun to explore the depths of the sea or the greater depths of the earth beneath the sea. Each undoubtedly contains something which can make life happier and more comfortable. Man is only beginning to control the wearing away of the rich soils and the prevention of destructive floods. He is only beginning to understand the story of the atmosphere and the currents of air which make weather and storms Ocean currents and tides are utilized but little, and the energy from the sun to only a small part of its possibilities.

WEIGHT AND RECREATION

The problem of weight is closely associated with recreation. Tired man yields to the force which holds him to the earth; and when he is full of energy he strives against this force. Athletic field-days and organized sports depend much on the pull of gravity. Without it balls thrown in baseball or tennis would not come down. High jumpers and hurdlers would sail off into space; troutflies would not fall lightly on the streams, which would of course cease their flow.

So universal and constant is this pull that athletic ability is measured in terms of mastery of it. The one who can throw himself or a baseball most accurately or quickly against the force of gravity is considered to have outstanding athletic ability. To standardize this competition the sizes of balls or the distances travelled have become fixed in most competitive sports. Some high-school records for New York State in various sports may help you to measure the excellence of your school mates or yourself.

According to the 1935–36 Yearbook of the New York State Public High School Athletic Association the track and field records established during state-wide championship track meets are as follows:

Event	Record	High school	Year
100-yard dash	9.8 seconds	Hempstead	1931
220-yard dash	21.6 seconds	Utica Free Academy	1926
		Hempstead	1931
440-yard dash	50.8 seconds	Rochester Technical	1924
880-yard dash	2 minutes, 10 seconds	Corning Free Academy	1931
Mile run	4 minutes, 31.4 seconds.	Mt. Vernon	1930
220-yard hurdles	25.6 seconds	Schenectady	1931
Medley relay	3 minutes, 32 seconds	Groton High	1930
		White Plains	1926
880-yard relay	1 minute, 33.4 seconds.	Dunkirk	1931
		Patchogue	1928
Pole vault	11 feet, 11 inches	White Plains	1926
12-pound-shot put	45 feet, 8 inches	Schenectady	1928
Running high jump	6 feet, 2.5 inches	Alleghany	1930
Running broad jump	22 feet, 7.25 inches	Riverhead	1931

These records do not equal records made by more mature athletes chosen on a world-wide basis, but they set standards which the readers of this Leaflet are more likely to approach.

A comparison of the relative speed with which man and his vehicles have moved over the earth shows that an airplane can travel a mile in 8.49 seconds; a racing automobile, in 12 seconds; a motorboat in 24 seconds; a bicycle in 57.8 seconds; a running horse in 1 minute, 32.8 seconds; a skater in 2 minutes, 37 seconds; and a running man in 4 minutes, 6.8 seconds. These figures are records, not the normal speed at which men have been able to compete with gravity. In every case the speed would be greater if wind resistance could be reduced.

WEIGHT OF ATHLETIC EQUIPMENT

Standards have been set also in the size and weight of athletic equipment so that records may be comparable. See how nearly the equipment in your school approaches the standards.

Ask your friends to tell you which balls used in sports weigh the most and to place them in order from the heaviest to the lightest. Then place them in order of their weight judged by weighing them in your hand. Then weigh them and compare the weights with the following standards:

A baseball should weigh from 5 to 5.5 ounces and should measure from 9 to 9.25 inches in circumference, that is, around the outside.

A football used in an official game must weigh from 14 to 15 ounces. It must have a lengthwise circumference of 28 to 28.5 inches, a short circumference of 21.25 to 21.50 inches, and a length of from 11 to 11.25 inches. It must be a leather-covered rubber bladder inflated to from 12.5 to 13.5 pounds of pressure.

A basketball must weigh from 20 to 22 ounces. Its circumference in any direction must be from 29.5 to 30.25 inches and it must be a leather-covered rubber bladder inflated to 13 pounds pressure.

A speedball must weigh from 17.5 to 19.5 ounces. It must be a leather-covered rubber bladder with a circumference from 28.5 to 29.5 inches and must be inflated to 12 pounds pressure.

A soccer ball must weigh from 13 to 15 ounces, must have a circumference of 27 to 28 inches and must be a leather-covered rubber bladder.

A standard softball must weigh from 6 to 6.5 ounces with a circumference of 12 to 12.25 inches. It must be leather-covered and smooth-seamed.

Official tennis balls weigh from 2 to 2 1/16 ounces. They have a diameter of from 2.5 to 2.625 inches. When dropped 100 inches onto concrete at a temperature of about 68° Fahrenheit they must rebound from 53 to 58 inches.

The United States Golf Association requires that a golf ball must not be less than 1.68 inches in diameter and that its weight shall not be more than 1.62 ounces avoirdupois. The better balls weigh from 1.6 to 1.62 ounces. According to J. B. Dickson, director of research of a prominent sporting-goods firm, no official rebound requirement is possible because dropping a golf ball gives only a superficial effect and may be totally misleading. He says, "When a ball is hit by a golfer, the flattening is much greater, being in the order of the size of a half-dollar, and much more of the ball comes into action instead of merely the surface of the ball as in a rebound test."

A polo ball is made of wood and must weigh from 4.25 to 4.75 ounces. Its diameter must not exceed 3.25 inches. These specifications seem less exacting than one would expect.

A hockey puck should be made of vulcanized rubber. It should be a disc one inch thick and 3 inches in diameter. It should weigh from 5.5 to 6 ounces.

Even the homely horseshoe which figures so prominently in rural sports has become standardized when used in nation-wide competition. A standard shoe for pitching quoits must be made of iron. It must weigh approximately 2.5 pounds. It must be 7.5 inches long, 7 inches wide, and have an opening of 3.5 inches.

In some sports, advantages associated with weight are recognized in many of the established classes. This is particularly true in wrestling and boxing. In other sports such as football the value of weight as against speed plays an important part in some positions as at guard and center. It does not follow that the heaviest person will make the fastest time in a running race.

WEIGHT AND LIFE

Different kinds of things and different individuals of any one kind may differ greatly in weight. The three little pigs of the nursery story were all of the same age and size; the three bears certainly were not. Age plays an important part in weight. Human life may be said to consist of three parts: youth, middle age, and old age. In the first of these, much energy is spent in building weight. In the middle period that weight is maintained or gradually increased. In old age some of it is likely to be lost.

What is true of human beings is also true of other living things. Frog tadpoles spend most of their energy in increasing the size of their bodies. When they get large enough and old enough they become adult frogs, and for the rest of their lives the increase in their weight is proportionately much less. What is true of frogs is also true of butterflies. The caterpillar stage is the period of great growth, when appetites are enormous and skins must be shed at intervals to make room for the increase. The adult butterfly does not increase in size but spends much of its energy in producing eggs which will grow into new caterpillars. The story is the same even when we apply it to the plant kingdom. We plant a radish seed and it grows for a considerable time, developing leaves and a large root. When the time comes, the nourishment stored in that root is used to produce flowers to produce more seeds. The same is true of most plants. See the Leaflet for November, 1933, to understand the periods of growth in forage plants.

Some things are worth knowing about this growth during the early part of life. It is not wise to try to have every person of a given age or a given height weigh the same as every other person of that age and height. In the past we have often taken the matter

WEIGHT VARIES WITH AGE
(From *Our Planet the Earth, Then and Now*, by Lillian Rifkin. Lothrop, Lee and Shepard)

of overweight and underweight too seriously. We have tried to do such things as make children whose ancestors have all been slender and tall weigh at a given age the same as children whose ancestors have been short and fat. In such cases we have run the risk of injuring health.

The important thing during the early years of one's life is not so much that one's height and weight conform with that of the average person of the same age as that growth is continuous. Growth will not be constant. It occurs in waves. At one time in life legs and arms may grow rapidly, while at other times other parts of the body may develop more rapidly. Proportionate increases in height and in weight may alternate. That is, for some weeks, months, or years, the increase in height may be proportionately greater than the increase in weight. A period may follow in which the proportionate weight increase is more rapid than the height increase. This variation is entirely normal and it corresponds to the building of a house, first putting up the framework and then adding the body and walls. It is important to note weight and height at intervals to see that growth continues when it is desirable. The following table shows *averages* in the height and weight of young people. It shows that proportionate increases in weight and height are not uniform. The figures should not be taken too seriously in comparison with your own height and weight.

TABLE OF AVERAGE HEIGHTS AND WEIGHTS

Age	Boys		Age	Girls	
	Height in inches	Weight in pounds		Height in inches	Weight in pounds
Birth.....	20.6	7.6	Birth.....	20.5	7.16
1 year.....	29.5	22.0	1 year.....	29.0	20.75
2 years.....	33.75	27.1	2 years.....	33.5	26.1
3 years.....	37.1	32.25	3 years.....	36.75	30.5
4 years.....	39.5	35.9	4 years.....	39.0	33.75
5 years.....	41.6	41.1	5 years.....	41.3	39.7
6 years.....	43.8	45.2	6 years.....	43.4	43.3
7 years.....	45.7	49.1	7 years.....	45.5	47.5
8 years.....	47.8	53.9	8 years.....	47.6	52.0
9 years.....	49.7	59.2	9 years.....	49.4	57.1
10 years.....	51.7	65.3	10 years.....	51.3	62.4
11 years.....	53.3	70.2	11 years.....	53.4	68.8
12 years.....	55.1	76.9	12 years.....	55.9	78.3
13 years.....	57.2	84.8	13 years.....	58.2	88.7
14 years.....	59.9	94.9	14 years.....	59.9	98.4
15 years.....	62.3	107 1	15 years.....	61.1	106.1
16 years.....	65.0	121.0	16 years.....	61.1	112.0

Many tables of the average heights and weights of adults of different ages have been published. No rule can safely be applied to all persons, but in general an adult five feet tall weighs 110 pounds. A person taller than this normally weighs an additional 5.5 pounds for every additional inch of height.

As suggested earlier, the rate of increase in size of different parts of the body varies. The distance around the head of a new-born babe and the distance around his chest are approximately the same. The following table will make clearer how rate of increase in size differs:

CIRCUMFERENCE OF HEAD AND OF CHEST

Age	Head circumference in inches	Chest circumference in inches
Birth	13	12.5
1 year	18	18.25
2 years	19	18.5
3 years	19.2	19.0
4 years	19.75	19.25
6 years	20	21.5
9 years	20.5	23.75
12 years	21	25.5

You learn about the location and functions of various parts of the body but most persons have little idea as to the relative size and weight of these parts. Most persons do not know whether a brain weighs more or less than a stomach.

AVERAGE WEIGHTS AND SIZES OF ADULT HUMAN ORGANS

Heart: 5 by 3.5 by 2.5 inches; weight, male, 10 to 12 ounces, female, 8 to 10 ounces.
Lung: decidedly variable; right, 23 ounces; left, 19 ounces.
Stomach: 10 to 12 inches by 4 to 5 inches; weight, 4.5 to 5 ounces.
Liver: 10 to 12 inches by 6 to 7 inches; weight, 45 to 60 ounces.
Kidney: 4 by 2.5 by 1.5 inches; weight, 4.5 to 5.5 ounces.
Brain: weight, male, 50 ounces; female, 44 ounces.

In a human brain the gray substance represents about 37 to 38 per cent of the total weight.

A great proportion of the body is water. Speaking generally, six chemicals make up 99 per cent of its weight. These are: oxygen, 65 per cent; carbon, 18 per cent; hydrogen, 10 per cent; nitrogen, 3 per cent; calcium, 2 per cent; and phosphorus, 1 per cent. The chemicals in the remaining 1 per cent are necessary and important. They include, in the

probable order of their abundance, potassium, sulfur, sodium, chlorine, magnesium, iron, iodine, fluorine, and silicon. Ordinarily the ashes from a cremated body weigh only from 2.5 to 11 pounds. The ashes of a 135-pound man may weigh more than those of a 160-pound woman. The large variation makes it unsafe to make broad generalizations.

In general, the weight of a full-grown person is about 20 times that of a new-born babe. In the first year, the child usually triples its weight. Although a girl baby generally weighs slightly less than a boy baby, at the age of twelve, boys and girls weigh about the same. A man normally attains his greatest weight when he is about 40 years old and begins to lose weight at 60. By the time he has reached 80, he may have lost normally about 13 pounds of his maximum weight and his height may have been reduced 2.75 inches. Women usually attain their maximum weight at about 50 years of age. Very old persons normally weigh about what they did when they were 19 years old.

If the whole problem of weight as applied to human beings is misunderstood it may lead to unfortunate results. An attempt to make size and weight conform to standards which are not appropriate may give rise to trouble, whether weight is modified to satisfy the demands of style or to suit one's convenience. If a person eats to excess he may again pay the price. Some knowledge of the foods which increase or decrease weight is important.

Some of the commoner foods which generally help increase weight are pork, butter, cheese, cream, dates, fried eggs, nuts, sugar, and whole milk. Some of those which help in reducing weight are soups made without fat, greens, fresh fruits, except bananas, and skimmed milk or buttermilk.

We sometimes think that the time when the world was populated with its largest animals has passed. Dinosaurs, at least the larger ones, have been well publicized. It is doubtful whether the huge weight of some of these dinosaurs was responsible for the disappearance of all of their group because some were no larger than cats, yet they have vanished too. The largest animals ever known to have lived on the earth have rivals in size living today. The largest of the dinosaurs was only about 75 feet long and raised its slender body up to a height of 15 feet. The huge sulfur-bottom whale, which still swims in some seas today, reaches a length of 105 feet and can hardly be called slender. While the weight of these large whales has not been accurately determined, some place the figure at close to 100 tons. The giraffe is not as long as was the ancient brontosaurus, but some specimens hold their heads at least five feet higher. The story of these early animals in Charles R. Knight's "Before the Dawn of History" was reviewed in the last number of the Leaflet.

A blue whale at birth has a length of about 26 feet and probably weighs about ten tons. During the first year, while it is still nursing, it reaches a length of 60 feet. It is said that a two-year-old whale may produce young. The average length of blue whales is 79 feet. Five whales of this species have been measured at more than 100 feet in length, one reaching 106 feet. All of these large whales were females. This female blue whale is, so far as known, the largest animal which ever lived on the earth.

Many animals make themselves appear larger or smaller than they are. During time of courtship it is a common custom for one or both of the individuals to attempt to magnify size and presumably weight in the eyes of the other. Also in time of danger it is a common practice for those on the defence, or those trying to frighten an opponent, to make themselves appear larger than they are. This holds true for cats, screech-owls, roosters, and nations. The padded shoulders in men's coats are only one of many devices employed by humans to make themselves appear bigger than they really are. See how many examples you can find of animals attempting to make themselves appear to have more weight than they really have. If you have an opportunity, read about the porcupine fish.

It may not be easy always to distinguish between weights without the use of scales. You could tell that something which really weighs only a pound does not weigh a ton; if the grocer gave you an ounce of sugar when you asked for a pound you would know it. But could you readily arrange in order ten objects which weigh from one to ten pounds? Try this on your friends, putting the weights in boxes of equal size so that the only apparent difference is weight. Psychologists say that a person who has a mentality of five years can distinguish between objects weighing one-tenth of an ounce and one-half of an ounce. With a reported mentality of nine years, one should, in two of three trials, arrange in order, in three minutes, equal-size boxes weighing respectively, 0.1, 0.2, 0.3, 0.4, and 0.5 ounces, or 3, 6, 9, 12, and 15 grams. Try these on yourselves and on your friends. Incidentally this Leaflet which you are reading weighs about an ounce and a half. How nearly could you or your friends have guessed this?

WEIGHT HERE AND THERE

So far in this Leaflet the things discussed have been such that you can, through your own experience, prove or disprove the statements which have been made. While you may see as far as the moon and sun and even beyond, you cannot go such distances to learn what exists in far-off space. Some experiments may help you to understand the situation.

Take a slender bottle or a test tube. In it put a spoonful of machine

oil. Does the oil float on top of the air or settle to the bottom through the air. Next add a spoonful of water. Does the water float on the oil, or the oil on the water, or do the two mix? Shake the bottle to see if this changes the situation, but give your judgment after the bottle has been allowed to remain undisturbed for some time. Next add a spoonful of white clay dust, chalk dust, or talcum powder, and again shake and let the whole settle. Then, if you can get it, add a spoonful of mercury. If you cannot get mercury, substitute fine lead shot, but this may make it necessary to stir the mixture thoroughly. If you use shot, try a larger glass dish and whirl the mixture. When all of these have been allowed to settle, which is at the bottom and which appear in order above it? Keep this order and this experiment in mind while reading the rest of this section of the Leaflet. It might be well to weigh a spoonful of each of the substances you have used to learn the relative weights of mercury, lead, air, water, oil, and soil.

As in your experiment, the portions of the earth have gradually arranged themselves so that the heavier are toward the center and the lighter toward the outside. A large proportion of the human body is water; hence, it is not surprising that living things generally are found in or near water. Incidentally, they are where there are both water and air. In places where these are lacking there are probably no living things.

Most of human life is spent comparatively near where air and water meet. Man may climb mountains, fly in airplanes, or dive into the lakes or the sea; but the distance up and down will not compare with the distance along the surface of land or water. Thinking of the earth as made of rocks and soils with water above and air on top of that, man really lives in the earth, not on it.

A few weeks before this Leaflet was written a friend asked me to ride with him from Washington to Philadelphia in his airplane. It was my first experience of the sort and matched, in a way, an experience in a submerged submarine off the coast of Hawaii. On each of these trips I left the part of the earth where I had customarily lived and was uncomfortable. On many occasions I have been higher above sea level than I was in the airplane, but I did not rise so suddenly, and good solid earth was always immediately under my feet. My aviator friend took me up a thousand feet and said that the air was so choppy that we ought to go higher. I agreed that it was uncomfortable so we went up another thousand feet. This continued at intervals of a thousand feet until I decided I had better refrain from expressing judgment. The solid earth looked to be a long distance from me. I knew that if the motor failed or an airplane wing gave 'way I would reach that ground too soon. As we came down from

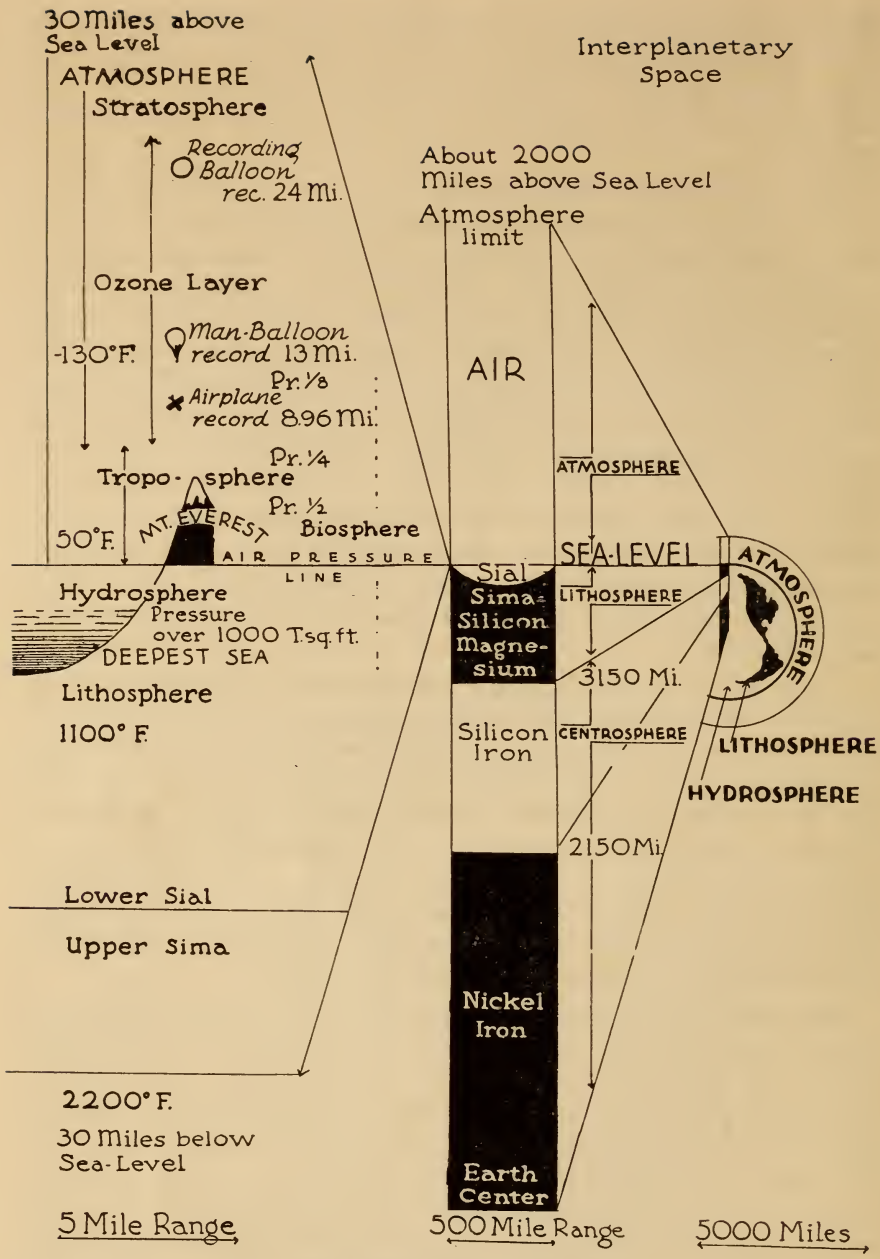
our trip into the atmosphere my ears "popped" and reminded me of the way they popped when I dived too deeply into the water. When I went down in the submarine I was protected from the pressure of the water outside by strong walls of steel and glass and did not feel the popping sensation.

The part of the earth which supports life is like a thin sheath which lies for the most part in the lower levels of the air and the upper levels of the water. This thin sphere, or shell, is sometimes called the *biosphere,* because it is the part of the sphere which supports life. As suggested, it includes the lower part of the atmosphere, or air sphere, and the upper part or most of the water sphere, or *hydrosphere.* This water sphere extends somewhat into the earth, or stone sphere, or *lithosphere.* The different kinds of life in these spheres depend largely on their ability to withstand the pressure of whatever may be above them. Creatures fitted to live in the depths of the sea if brought to the surface will practically explode; you would be made uncomfortable if you were taken high into the air. Incidentally, if you were able to go off into space away from our earth you might come to a place where you no longer had weight and from where you might, theoretically at least, be drawn to the moon or to some other body out in space.

If you climbed the world's highest mountain, Mt. Everest, which reaches 29,002 feet above the level of the sea, in going up that short distance of a little more than 5½ miles you would pass through the area in which most rain clouds are formed. An airplane has been flown to between three and four miles higher, up at 47,364.67 feet, or 8.96 miles, but at that level it would be impossible for man to live, except by artificial means and for a short period, because of the nature of the air. The sketch and table show the various shells which have been recognized as lying one outside the other above that part of the earth with which man is most familiar. The landmarks on the way up might be as follows:

Lower levels of atmosphere from sea level to 6 or 7 miles are known as the *troposphere.* Life is most abundant in the lower two or three miles of this and generally is there confined to the surface of the ground. Average temperatures are about 50 degrees Fahrenheit. At a height of 5.576 miles, the highest point of land is passed. Breathing is difficult there and most clouds would have been passed.

Levels of atmosphere from 7 miles up are known as the *stratosphere.* In the region from 7 to 25 miles above the sea the temperature averages around 130 degrees below zero. At this height, air is much lighter than the same quantity close to the ground and heavier than an equal quantity above. This region from 7 to 25 miles above the sea is known as the ozone layer



THE REGIONS OF OUR EARTH

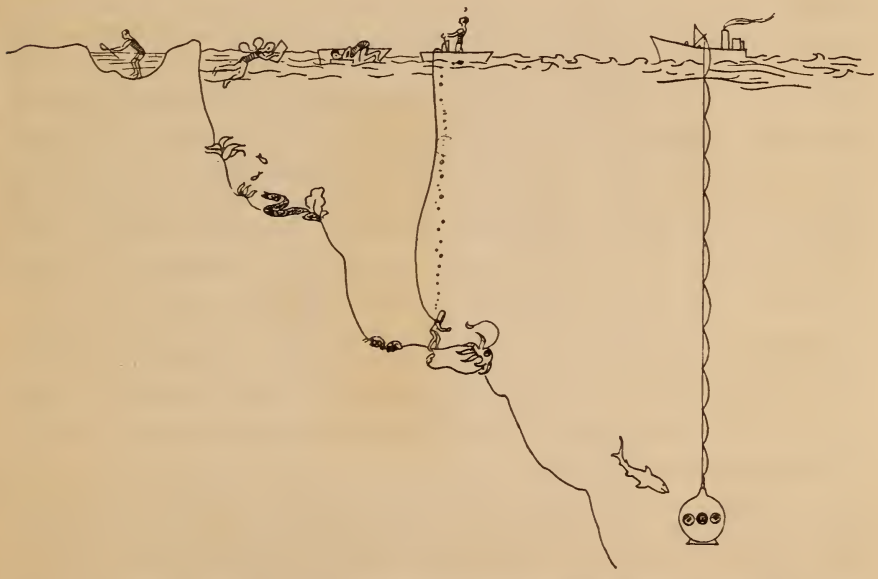
After this diagram was made, a manned balloon rose to a height of almost 14 miles above sea level on November 11, 1935

or perhaps better, the ozone shell. The highest point in it ever reached by man in a balloon is almost 14 miles above sea level; 24 miles is the highest point to which man has ever sent a balloon with recording instruments.

A shell of the stratosphere, 25 miles thick, which lies above the ozone layer, and extends from 50 miles to 75 miles above the sea, is important because the atmosphere there reflects radio beams or waves and thus makes world-wide radio reception possible. Outside this earth-shell and extending from 40 to 150 miles above the sea, is a layer of the stratosphere in which the Northern Lights make their appearance. Farther outside this and extending to possibly 2000 miles above the sea the air is more and more rare. The outer limit of this layer probably marks the limit of the atmosphere.

If man could go in the opposite direction from the surface of the ground and make his way underground, he would find, as in the experiment with the mercury, clay, water, oil, and air, suggested on page 26, that the heavier things were towards the center of the earth.

Obviously, some of the ground rises above the sea and some of it is beneath the sea. When ships sink they "go to the bottom." If you could go down with one of these ships you would see that most of the living things would be near the surface. No man has gone more than a half-mile down and lived. To see anything at that level he would have to bring



FROM BULLETIN OF THE NEW YORK ZOOLOGICAL SOCIETY

METHODS OF STUDYING MARINE LIFE AT VARIOUS DEPTHS

lights with him. And to withstand the pressure of the water and the air above he would have to encase himself in a sphere stronger than any yet made. The deepest place in the sea or hydrosphere (water sphere), to which you could go would be almost exactly 6 miles below the level of the sea. This is only a little farther below sea level than Mt. Everest is above sea level.

The 11½-mile sphere which would be bounded by the greatest depth of the sea and the greatest height of land would include the regions in which life might be found, the biosphere. Compared with the rest of the earth, both inside and out, it is little more than a film in the whole. It would be proportionately as thick as a piece of tissue paper pasted on the outside of an 18-inch globe. You may see from this that it is absurd to say that life is found everywhere. Such a statement is far from true.

The ground which you think you know so well is not entirely as it appears on the surface. The Leaflets "Rocks and Minerals" and "Made of Earth" told you that much of this ground is made of sand and quartz, a considerable proportion of which is silicon. Much of this ground is also clay, much of which is aluminum. If you make a word of the first two letters of each of the words *silicon* and *aluminum,* you have the term *sial.* This term is applied by many to what you would recognize as ground. In your initial experiment with this section, it would compare with the clay which settled through the air and water and floated on the mercury. Much as the clay in your experiment floated on a heavier substance, the ground which you recognize is believed by some to float on a heavier substance. This is composed largely of silicon and magnesium about both of which you have probably heard. A name for this sphere inside the sial is the *sima,* and you will understand now how the name was chosen. The sial and sima layers together make up what is known as the lithosphere or stone sphere. They are not uniformly thick throughout the earth any more than the sea is uniformly deep. The sial normally is about 21 miles thick and has an average temperature throughout of about 1100° F. The inner sima layer is about 700 miles thick and has a temperature of around 2200° F. These two layers are for the most part inside the hydrosphere and atmosphere, but outside a central sphere which, for the want of any better term, might be called the *centrosphere.* Each of the layers must support all that is above it, so you may get some idea of the pressure which exists.

By studying impulses sent through the earth by earthquakes and by other means, men have learned something about this inner centrosphere. Some clue to this means of studying the harder part of our earth was given in the Leaflet entitled "Sound." We know from these and other

studies that the outer shell of this centrosphere, which is just inside the sima, probably is composed largely of silicon and iron. This shell is about 1000 miles thick, and surrounds an inner sphere composed largely of nickel and iron. This must be in a molten state judging from the way it responds to disturbances such as those created by earthquakes and because of other evidence. This ball is not a shell like the other regions we have been discussing. It has a diameter of about 4300 miles, or extends out from the center of the earth for about 2150 miles.

If the inner portion of the earth were not composed of the heavy material with the like of which you have experimented, man would not weigh as much as he does, for the weight of any object depends upon the mass or weight of the body with which it is associated. If the earth were made of the same material but were smaller man would weigh less. If it were made of the same materials and were larger man would weigh more. If it remained the same size but were made of a larger proportion of heavier materials than it now is man would weigh more. Under what circumstances would man weigh less than he does with the earth remaining the same size? The earth, as it is, weighs 5.57 times as much as it would weigh if the part now occupied by land and water were occupied wholly by water at its normal density. If a man who weighs 173 pounds could live on such an earth he would weigh only about 31 pounds. How much would you weigh?

To give you some idea of how weight would vary on some heavenly bodies the following may be helpful. On the earth's lithosphere at sea level under normal conditions, 100 pounds weighs 100 pounds. On the moon, a person who weighed 100 pounds on the earth would weigh 16.5 pounds. On Mercury he would weigh 25 pounds; on Venus, 85 pounds; on Mars, 36 pounds; on Jupiter, 264 pounds; on Saturn, 117 pounds; on Uranus, 92 pounds; on Neptune, 112 pounds, and on the sun, 2760 pounds. Which of these bodies do you assume to weigh more and which to weigh less than the earth?

The pull which these bodies exert on the earth depends not only on their size and weight but upon their distance. For example, the moon is much smaller than any of the planets but it happens also to be much nearer. For this reason it exerts a conspicuous influence.

This matter of weight and the attraction of one celestial body for another has a number of interesting consequences. Possibly the most conspicuous evidence that there is such an attraction outside the attraction of the earth, is the way in which the moon affects the earth's seas. It is the pull of the moon on the fluid seas which makes tides. If the moon weighed less than it does tides would be lower. If the moon were heavier, tides would

be higher. Furthermore, the pull which the sun exerts is also reflected in the tides and accounts for some of the exceptional high or low tides.

Since the moon is swinging around the earth about once a month, once a month the pull of the moon and the sun will combine on the same side. Once a month, too, they will be pulling in opposite directions. At two other times the moon and sun will be pulling at right angles to each other.

The highest tides, then are when the moon is nearest and also when the sun is nearest, or about January 1. The weakest, or least high, tides will be when both the moon and the sun are farthest away, or about July 1. Weak tides also occur twice a month when the moon and sun are pulling at right angles to each other.

This whole story will be further developed in a later Leaflet, devoted to the sea.

The relative weights of warm and of cold water, as discussed in the Leaflet on heat, are partly responsible for ocean currents. In almost the same way, the relative weights of warm and of cold water and their behaviors help us understand why lakes freeze over and do not normally freeze solid. Once the temperature of the whole lake has been reduced sufficiently near to the freezing point by the settling of the heavier cold water and the rising of the warm water to the cold air, ice forms at the surface and makes a blanket which slows the freezing process.

The relative weights of warm and of cold air are responsible for significant air disturbances. These are important in matters such as the ventilation and heating of homes and in the whole problem of weather. Problems concerned with these topics were touched on in previous numbers of the Leaflet. A forthcoming number on weather will develop that topic. Because of differences in the weight of the air and water about man, he lives in an environment which is almost constantly changing. Air and water as they appear in nature are seldom stationary. In the lower levels of the atmosphere and the upper levels of the lithosphere they are being mixed up and down and back and forth in clouds, streams, tides, and ground water. This constant change brought about by heat, and weight, the subject of this Leaflet, make it possible for us to live comfortably over much of the relatively dry ground that rises out of the water into the air.